Effect of buffer layer, annealing and composition on inverse giant magneto-resistance (GMR) arising from negative spin polarization of Fe_xCr_{1-x}

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Microwave assisted magnetic recording (MAMR) is expected to overcome the areal density limit of the current perpendicular magnetic recording technology. It relies on the energy assist from ac magnetic field generated from a spin torque oscillator (STO) placed in the vicinity of the write head. For this STO to generate sufficient frequency and energy of the ac magnetic field with small dc current density, a suitable choice of materials for spin injection layer (SIL) and field generating layer (FGL) is necessary.

Barnas *et al.*[1] have noted that using a negatively spin polarized SIL, a large spin transfer torque (STT) can be generated close to the parallel configuration of the two ferromagnetic layers, as opposed to the anti-parallel configuration that is necessary for positively spin polarized SIL. It has already been reported that FeCr[2] is one such material having negative bulk spin polarization (β), resulting in an inverse GMR. An earlier study[3] demonstrated the reduction of threshold current density for the STT-induced magnetization oscillation using FeCr. However, yet-to-be-answered questions include the role of interfacial spin polarization (γ) as opposed to bulk spin polarization (β) and the phase stability of FeCr under annealing process. The choice of buffer material is expected to influence the growth of FeCr film, thus the spin polarization of the FeCr film.

To study the effects of buffer layer and annealing in detail, we made a range of CPP-GMR devices with $Fe_{1-x}Cr_x$ (5 nm)/Cu (3 nm)/$Fe_{68}Co_{32}$(5 nm) as the main GMR stack, with various buffer layers. Figure 1(a) shows the structure of the sample where the buffer layer y is chosen among {Cu(3 nm) /$Fe_{68}Co_{32}$(5 nm), Ru(2 nm), Ru(2 nm)/Cr(3 nm), Ru(2 nm)/Cu(3 nm)}. For each buffer layer, three different structures were made with $Fe_{1-x}Cr_x$ composition chosen among {x=0.2, 0.3 and 0.4}. For each structure, we microfabricated pillar shaped CPP-GMR devices on as-deposited films and then annealed at 220°C for 5 hours. Figure 1(b) shows an example of inverse GMR arising from negative spin polarization of FeCr layer grown on Ru(2 nm). Our study shows that buffer layer strongly influences the inverse nature of the CPP-GMR ratio. While annealing does not cause any phase separation, there is no significant variation of the magnetoresistance (MR). In terms of composition, higher Cr percentage is more desirable .

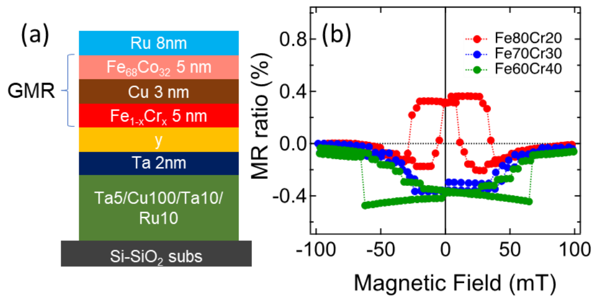

Figure 1. Inverse Giant Magneto-Resistance in $Fe_{1-x}Cr_x$(5 nm) /Cu(3 nm)/$Fe_{68}Co_{32}$(5 nm) (a) Film structure (b) Resistance vs Magnetic Field measurement showing inverse MR ratio for y=Ru(2 nm)

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[2] C. Vouille *et al.*, *Phys. Rev. B - Condens. Matter Mater. Phys.*, vol. 60, no. 9, pp. 6710–6722, Sep. 1999.

[3] Shimizu *et al.*, *The 39th Annual conference on Magnetics in Japan* 10pE-3, 2015.